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THE DURATION OF NIAGARA FALLS.

BY DR. J. W. SPENCER.[1]

For the past century Niagara Falls has been considered a time measurer, but its greatest interest has risen since the growth of our knowledge of the Ice Age on account of the expectation that in some way it can be made to tell something of the date of that period and indirectly of the advent of man, or his restrictions on account of the glacial conditions. The paper of which this is an abstract was primarily a physical study, setting forth the changing episodes in the history of the falls, and computing the age of the river, but leaving to others the application of the results in the question of early man.

The method of determining the age of the falls is the application of the mechanics of the river to the various conditions during the changing episodes of its history, in a large measure discovered by the author during the last fifteen years. The investigation differs from those of other writers who have simply divided the length of the chasm, excavated by the retreating falls, by the imagined or measured rate of the recession of the cataract. At a glance, even the most superficial reader can understand that if the height of the cataract be first reduced to one-half, and then again doubled, or if the volume of the river be reduced to one-fourth, such variations are bound to produce as great changes in the rate of recession as are indicated by the mechanical laws; and that if the conditions have not always remained constant, then the present rate of retreat has not always obtained—sometimes slower and sometimes faster. It is this question that the paper considers for the first time. In the much written, but, until recently almost unknown, history of Niagara River, we find that an approximately correct estimate of the age of the falls was made half a century ago by Lyell, upon a conjecture of the rate of recession now known to be wholly erroneous. Again, within the last eight years, there have been several writers who have been using corrected cöefficients of retreat, still their results are more inaccurate than the guesses, as to the age of the falls, made a hundred years ago, yet they may be said to have approximated the truth within their observations, but the observations have become enlarged.

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[1] Abstract of a paper read before the Am. As. Ad. Science at Brooklyn, August, 1894.

A hundred years ago, Andrew Ellicott estimated the age of the falls at 55,000 years. Forty years later, Bakewell made the falls about 12,000 years old. Over fifty years ago, Lyell conjectured the age at 35,000 years, and this estimate was commonly accepted until about a decade ago. The foundations for the measurements of the retreat of the cataract were laid by Professor James Hall, when he made the first preserved instrumental survey of the cataract in 1842. Since then, measurements have been repeated in 1875 by the Lake Survey; in 1886 by Professor W. S. Woodward, and in 1890 by Mr. Aug. S. Kibbe. From these surveys the mean rate of modern recession of the falls is found much more rapid than was formerly supposed, as it amounts to 4.175 feet a year, and if the history of the falls had been uniform, then the age would have been only 9,000 years—not so different from the guess of half a dozen years ago, which took the maximum medial retreat of the cataract, and made the age only 7,000 years. Had the gentlemen taken the mean rate as then known, which the scientific methods dictated and since supported by the action of the river, they should have made the age of the falls 11,000 years, near which estimate some did. This point is noticed on account of many secondary writers finding the number 7,000 years as agreeable to their theories.

Owing to some structural variations, I have taken 3.75 feet a year as the mean rate to be adopted for the retreat of the falls mechanically applied to the different conditions of the river. These have been occasioned by the changing heights of the falls and the volume of the water. With regard to the latter point, it has been found that for three-fourths of the duration of the river, the drainage of Lake Huron and the upper lakes was by way of the Ottawa River, and not by way of Lake Erie and the Niagara. Under these conditions only $\frac{3}{11}$ of the present discharge of the Niagara River cascaded over the falls. The episodes of the river are as follows: First episode: water descending 200 feet, volume $\frac{3}{11}$ of the present (when the falls was of about the magnitude of the present American cataract), chasm excavated (as shown by the position of terraces) 11,000 feet; time required, 17,200 years. Second episode: descent of the river in a series of three cascades aggregating 420 feet at first with only the Erie drainage (during the recession of 3,000 feet) and afterwards the present volume of water (when the recession amounted to 7,000 feet) duration 10,000 years. Third episode: river descending 420 feet in one cascade with the present volume; time required, for the recession of 4,000 feet, only 800 years. Fourth episode was somewhat complicated, with the water mostly descending 320 feet, and during this condition the falls have receded 11,500 feet, and required a period of 3,000 years. Thus the age of the falls has been computed at 31,000 years. But at the beginning, the river flowed from lake to lake without a falls, and this time has been taken as 1,000 years; accordingly, the age of the river is computed at 32,000 years. The record of the changing levels may be seen in the deserted beaches now high above the lakes which have already been described in scientific journals. The investigations doubtless contain some errors which may be corrected in the future, but in the history of the lakes the present computations are very strongly confirmed by much cumulative evidence so that the present results appear to be approximately correct. It is further estimated that with the earth movements continuing as at present, the end of the falls will be effected by the change of the drainage from the Niagara River to the Mississippi, by way of Chicago, owing to the rise of the eastern rim of the Erie basin above the barrier now separating the lake waters from the Mexican drainage. With the present rate of elevation continuing, the future life of the river ought to be 5,000 or 6,000 years.

In regard to the relation of Niagara River to the Ice Age, I estimate that the lake epoch commenced from 48,000 to

64,000 years ago, and that for several thousands of years before the birth of the river there was open water far northeastward of the river. Some writers think that the St. Lawrence Valley was obstructed by ice until a late date. This is a question to be determined; but however it may be, there has been free communication for the drainage of the Ontario basin for at least 14,000 years. Whether the end of the Ice Age were 60,000 or 14,000 years ago, all glacial obstructions had retreated to at least from 400 to 600 miles to the north and east of the Great Lakes fifty milleniums ago. The lake region was roamed over by mastodons, elks and beavers, but we do not know of the presence of man. If such be found, anthropologists will have all of these years to consider in fixing the antiquity of man. The story of Niagara River forms an interesting chapter in the physical growth of the lakes, and gives us an approximate idea of the duration of the lake epoch which was characterized by the last touches in the fashioning of the continent, and fixes the height of the Ice Age a very long time ago.

One point more should be noticed. An error has prevailed for fifty years in that it was supposed that the ancient Niagara drainage was by way of the Whirlpool, (St. David's) Ravine. This has been found erroneous, owing to the occurrence of rock across the Whirlpool Ravine at an elevation of about 170 feet above the surface of Lake Ontario.